REVEGETATION

TOPSOIL REPLACEMENT

DESCRIPTION

Loading, transport, and spreading of topsoil is the last major earthmoving operation in remediation of a mine site. If replaced topsoil is allowed to erode, not only is site damaged, but the lost soil must be replaced again at additional cost.

In general, topsoil is more easily eroded than rocky backfill, and topsoil is vulnerable to erosion until revegetation stabilizes surface soils. During this vulnerable period, erosion control devices and measures must be used to protect topsoil. This section discusses only control measures specific to topsoil. Refer to the section on Sedimentation and Erosion Control for additional information.

Cost: $0.40 to $1.50 per cu yd.

CONSTRUCTION

* Construct erosion and sedimentation measures prior to topsoil replacement.

* Replace and spread topsoil immediately prior to longest precipitation period or when moisture is most favorable for planting. Refer to the sections on Topsoil Removal Reshaping Highwalls and Roads, and Waste Dump Mitigation for guidelines on topsoil thickness.

* Apply acidic (lime) or alkaline treatments as recommended in Reshaping Highwalls and Roads. Soil pH should range from 5.0 to 7.5.

* After applying topsoil, rip surface to eliminate compaction, failure plane between layers, and preferential pathway for subsurface water. Ripping also promotes root depth and water infiltration.

  ** Ripping machinery includes dozer and grader rippers or rakes, loaders with bucket teeth, subsoilers, and klodbusters.

  ** When surface is dry, insure ripping shatters mantle. For thick topsoil layers, rip twice once before and again after applying topsoil.

  ** Deep ripping should be 2 to 3 ft deep on 2 to 3 ft centers. Distance between rippers should be equal to ripping depth .

** Rip on contour.

** Raise ripping depth if it brings excessive rock to surface.

* Fertilize site as described under separate guideline.

* Disk or harrow to smooth surface.

* Plant site with a drill or cultipacker type seeder to assure seeds are planted at proper depth, and have hydraulic contact with soil.

** For broadcast seeding, plant immediately after harrowing so that soil will settle around seed. Use a light chain, log drag or roller, where possible, to cover seed.

REFERENCES: This section paraphrased from PDER, 1978, p. 8 & 13; USFS, no date, p. 15.

FERTILIZATION AND SEEDBED PREPARATION

DESCRIPTION

Native soils of mine sites are often nutrient deficient, and topsoil salvage often dilutes existing nutrients. Soil should be analyzed prior to revegetation, see the section on Site Characterization and Monitoring.

Nitrogen and phosphorus are frequently deficient on mine sites, whereas potassium is usually adequate. Nitrogen deficiency is characterized by stunted growth, yellow leaves, and drying of the lower parts of plants. Phosphorus deficiency often causes a purplish color with very little stooling or spreading and poor seed production. These deficiencies generally have a more pronounced effect on grasses than on forbs, and where revegetation is predominantly grasses, fertilization may be necessary.

Nevertheless, on some modern mine revegetation projects fertilization has diminished because plant species dependent on high fertilizer rates have been removed from seed mixes. In addition, experience indicates that nitrogen fertilizers encourage vigorous growth of weeds and the more aggressive native grasses, to the detriment of less aggressive natives including woody plants.

Soil moisture influences the beneficial effect of fertilization. Nitrogen and phosphorus must be in soluble forms for plant consumption. On arid sites, fertilization may not be beneficial, because after precipitation, plants may utilize moisture before it dissolves the fertilizer.

Factors that affect revegetation include soil texture, depth, and alkalinity; site elevation, gradient, aspect, and wind exposure; and precipitation and temperature patterns. Because these factors are site specific, mine site revegetation must rely on local practices. What follows in this section are guidelines on how to start thinking about revegetation. In addition, sources are given for more detailed regional revegetation information.

Cost: $100 to $500 per acre.

GUIDELINES

* Where possible, replace topsoil directly without interim storage. Direct haul topsoil provides organically rich and biologically active medium which dramatically improves establishment of planted and volunteer species. Stockpiled soils deteriorate biologically after 2 to 4 years.

* Seedbed preparation may not be necessary if seeding is done immediately after grading. See Topsoil Replacement. Seedbed preparation scarifies the surface to reduce soil compaction and surface runoff which in turn enhances infiltration and root penetration. Common implements include discs, chisel plow, harrow, and ripper. On rough, rocky areas use heavy-duty equipment such as the offset disc or brush harrow. On severely compacted areas, use rippers.

* If necessary, apply mulch to conserve soil moisture and aide erosion control.

* Concern over early revegetation success and erosion control has led to irrigation. However, vegetation developed slowly under dryland techniques may reach the same level of cover in the long run as irrigated areas.

  ** Where erosion is a concern, two-stage planting or nurse crops may be applicable. Quick response grasses, legumes, and forbs are planted, followed in one to three seasons with trees and shrubs.

* Test soil and growing medium for nutrient deficiencies prior to undertaking any kind of revegetation. Refer to Site Characterization and Monitoring.

* Nutrient content of bagged and bulk fertilizers is expressed as a percent of content by weight.

  ** A 100 lb bag marked 5-10-5 contains 5% nitrogen (N), 10% phosphorous (P_2O_5), and 5% potash (K_2O_5).

To apply 20 lb per acre of phosphorous, it would require 20 / 0.1 = 200 lb of fertilizer mix.

* Consider fertilizing with materials other than commercial products such as cattle manure, poultry manure, treated sewage sludge, and fly ash. All municipal and industrial sludge must be tested for heavy metals content. Lifetime leaching rates of heavy metals cannot be exceeded. Get technical advice from the local office of the Soil Conservation Service when applying these materials.

* Apply fertilizer with spreaders, hydroseeders, or aircraft. It also can be mixed with seed and mulch in a hydroseeder and applied in one pass. However, the mixture should be spread soon after mixing to avoid seed damage by fertilizer.

* Extremely acidic or alkaline soils limit plant growth. See Reshaping Highwalls and Roads for soil treatments.

REFERENCES: This section paraphrased from PDER, 1978, p. 14; Thorne, 1987, p. 38 & 55; USOTA 1986, p. 76; USFS, no date, p. 25.

SEEDING AND TRANSPLANTING

DESCRIPTION

The goal of revegetation at AML sites is to reestablish plant communities similar to premining vegetation, except where post mining land use is different from premining use, or where premining vegetation was poor quality. Species suitability is determined by site and environmental characteristics, and species adaptability and availability. Macro- and micro-environmental factors such as gradient, aspect, and elevation control local plant distribution within a landscape. Generally, native species must be used for reclamation in National Parks.

Cost: $100 to $300 per acre (does not include transplanting).

MATERIALS

Plant species suitable for adverse conditions:

Moderately Acid Soils

Agrostis Tenuis (Common bentgrass)
Deschampsia ceaspitosa (tufted hairgrass)
Poa alpina (Alpine bluegrass)
Phieum pratense (Common timothy)
Carex spp. (Sedges)

Achillea millefolium (Yarrow)
Sibbaldia procumbens (Creeping sibbaldia)

Moderately Saline Soils

Festuca arundinacea (Tall fescue)
Agropyron desertorum (Crested wheatgrass)
Agropyron elongatum (Tall wheatgrass)
Distichlis stricta (Desert saltgrass)
Lotus corniculatus (Birdsfoot trefoil)
Eriogonum umbellatum (Sulfur eriogonum)
Atriplix spp. (Saltbush)
Atremisia spp. (Sagebrush)

GUIDELINES

Species Selection

* Observe plant species found growing naturally nearby or on old disturbances near the site to be revegetated.

* Consider plant species that establish quickly to prevent erosion and build root biomass.

* Consult applicable research reports and papers regarding revegetation.

* Consult with NPS experts and Soil Conservation Service county agents.

Seed Acquisition

Seed either may be collected from plants in the vicinity of the AML site or purchased from a seed dealer. Seed collection may be expensive. General guides to seed collection include:

* Locate stands of desired species before seed matures.

* Collect seed only after it matures on the plant. Different species mature at different times; therefore, seed acquisition of various species may require several collection trips.

* Collect by hand-stripping or using a mechanized device designed for the purpose.

* Place seed in either cloth or paper bags, never seal in plastic. Plastic retains moisture and causes molding.

* Clean and separate seed from chaff and other debris as soon as dry.

* Store clean seed in a cool dry location in paper or cloth bags.

If seed is purchased, take the following precautions:

* Ensure that stock is made up of desired varieties, and verify date of collection.

* Specify germination percentage, collection location, species name, pure live seed, and maximum allowable weed or other contamination.

* Use Plant Material Centers of the Soil Conservation Service for information about seed and seed dealers.

Seeding Method

Drill seeding is primarily used for small seeded species such as grasses, legumes, and some shrubs.

Advantages: Less seed is required than other methods. When used on contour, surface runoff is slowed by furrows created by the drill.

Disadvantages: Limited to areas relatively free of stones, and hillslopes less than 3h:1v. Site must be level enough for use of farm equipment. Uniform seeding depth may preclude successful establishment of all seed species.

Broadcast seeding is beneficial in small or remote areas. When broadcast seeding, plant immediately after site disturbance so that soil will settle around seed. Use a light chain, log drag, or roller to cover seed.

Advantages: Fast, cheap, and results in a more natural looking stand. Requires only primary tillage, whereas drill seeding requires a smoother surface.

Disadvantages: Requires twice the seed rate as drilling because of uneven seed dispersal, poor coverage of seed, predation, and excessive drying if precipitation is inadequate.

Hydroseeding is a process where seed is mixed with water and sprayed onto a site. Fertilizer, mulch, and lime may be added to mixture.

Advantages: Provides moisture for immediate germination. Slurry agitation in hydroseeder may promote scarification of some hard-coated seeds thus enhancing germination. One step process of soil

treatment - seeding, fertilization, mulching, and initial watering.

Disadvantages: Some seeds are damaged by process. Time of planting is critical.

* Seeding rates:

Seeding Method	Arid West (lb/acre)	Other Areas (lb/acre)
Drill	10 - 20	5 - 10
Broadcast	20 - 40	10 - 20

Where rainfall is less than 10 in. per yr, use transplanting.

* Schedule seeding just prior to longest period of precipitation or when moisture is most favorable for seed establishment.

* Protect seedlings from grazing until fully established.

Transplanting

Transplanting is labor intensive and expensive; however, it may have particular application to National Parks where introduction of specific plant communities is crucial to remediation objectives.

Survival and performance of seedlings is dependent on good quality stock, lifting date, methods of storage and handling, site conditions, weed competition, planting methods and spacing, fertilization, watering, and animal damage. Consult with NPS experts and Soil Conservation Service county agents.

* Protect transplants from competition by scalping the cover or applying herbicides before planting. Alternatively, inoculate seedlings with superior types of mychorrizal fungi.

* Protect transplants from browsing animals with high fences around entire site, poultry netting around individual trees, and polyethylene sleeves around trunks.

There are three methods of transplanting, as follows:

Bare-root seedlings

Advantages: Much cheaper than containerized stock. Bare root seedlings are usually dormant when shipped, and don't require hardening off.

Disadvantages: Transplanting success may be limited if stock is poor, soil moisture is inadequate at planting, or roots are not placed properly and are doubled under or crooked. Must be planted within 2 weeks of delivery. A dry, hot wind can dry out roots and kill seedlings in a very short time.

Containerized seedlings

Advantages: Longer planting season. Requires less experienced planters. Container stock may be the only viable alternative on harsh sites.

Disadvantages: Higher purchase cost, and more labor intensive planting. More susceptible to frost heaving. Require constant moisture prior to planting.

Live pads

Advantages: Transplanting pads or clumps of native vegetation provide an immediate source of mature growing plants. Pads are more immediately effective than other methods, and can be used in any location that is accessible to machinery.

Disadvantages: Distance between source and revegetation site is limited. Long haul distances damage pads and increase costs. Damages source areas.

REFERENCES: This section paraphrased from PDER, 1978, p. 14; Thorne, 1987, p. 55; USOTA, 1986, p. 76; USFS, no date, p. 22.

MULCHING

DESCRIPTION

Mulches protect and stabilize soils until permanent plant cover becomes established. Mulch reduces rainsplash, surface wind, particle movement and other erosional effects. In addition to preventing erosion, a good mulch cover protects seeded areas from the severe effects of heat, cold, and drought. On the other hand, mulches sometimes immobilize nutrients, inhibit germination, contain weeds, and attract plant diseases.

Considerations in the selection of a mulch type include mulch effectiveness, cost, time of seeding, proposed land use, climate, topographic features, and application methods.

Cost: $300 to $500 per acre.

GUIDELINES

General

* Dark colored mulch raises spring soil temperature, and light mulch reduces summer soil temperature.

* Apply mulch to roughened surface and anchor. Anchor methods include:

  Manual anchoring ties down mulch with stakes, pegs, twine, or netting. Applicable to small, steep, or windy sites.

  Mechanical anchoring partially buries mulch in soil by crimping, discing, or rolling.

  Chemical anchoring sprays a tacifier onto mulch. Can be included in slurry for hydroseeding. There have been some difficulties in using chemical anchoring, get help from experts.

* Mulch can be applied by hand on sites up to 1 to 2 acres in size, and gradients less than 3h:1v. Larger and steeper sites require a power blower or mulcher.

* Mulch application rates are given in Table XI.

TABLE XI
TYPICAL MULCH APPLICATION RATES

Mulch	Seed Cover	Erosion Control	Plant Mulch
Straw, ton	1.5-2	3	4
Hay, ton	2	2	2
Manure, ton	10-15	30-40	40-60
Hardwood Bark, cu yd	45	240	480
Softwood Bark, cu yd	45	240	480
Hardwood Chips, cu yd	50	268	536
Softwood Chips, cu yd	50	268	536
Sawdust, cu yd	275	550	825
Leaves, ton	3	4	5
Solid Waste, ton	20	---	---
Sewage Sludge, ton	75	---	---
Wood-Cellulose Fiber, lb	1 500	3,000	---

REFERENCE: Thorne, 1987, p. 48.

Live Mulching

Before topsoil removal, create mulch by shredding woody plants and removing with topsoil, rather than uprooting and discarding plants.

Advantages: Leaves a residue of chopped organic matter on soil surface that is removed along with topsoil. Some contained roots may sprout resulting in better densities than achieved by seeding and transplanting alone. Allows complete topsoil salvage in contrast to clearing and grubbing which wastes vegetation and soil clinging to roots.

Disadvantages: Only applicable to areas newly disturbed.

Straw/Hay Mulch

Advantages: Least expensive. Usually contains seed of grasses and legumes that may help revegetation.

Disadvantages: Contained seed may compete with preferred seed species, and weedy species may be introduced. Usually decomposes and becomes ineffective after one growing season. May be a fire hazard in dry weather. May immobilize soil nitrogen. Anchoring may affect soil microbial cycling and nitrogen availability which in turn may require additional fertilization.

Bark Mulch

Advantages: Hardwood bark is effective for 3 to 4 yr; softwood bark remains intact for 5 to 10 yr. No anchoring is necessary. Source for microorganisms and phosphorous. Trap for moisture and airborne seeds. Moisture retention can be adjusted by changing the particle size distribution. Bark may be composted which removes toxins and accelerates formation of humic acid.

Disadvantages: Soil nitrogen decreases as bark decomposes, and often nitrogen fertilizers must be applied. Too much fine bark may cause rapid decomposition, soil compaction, undesirable dust, and fire hazard. With the exception of cypress and cedar, softwood bark is more likely to move than hardwood bark in runoff or heavy wind.

Wood Chip Mulch

Advantages and disadvantages are generally the same as for bark mulch with the following additions:

Advantages: Does not favor insects or rodents.

Disadvantages: Decomposes slightly faster than bark due to cellulose content. Should not be stored outside for more than 3 to 4 mo because high temperatures will dry chips and kill beneficial microorganisms. Chips can inhibit seedling or grass emergence.

Sawdust Mulch

Advantages: Adds nutrients to soil, and absorbs water 2 to 6 times its own weight. Effective for 3 to 5 yr.

Disadvantages: Must be well-leached and stored for about one year. Tends to pack tightly and retard aeration and water infiltration. Slightly acidic which is not a disadvantage unless it necessitates liming. Must be anchored with tacifier. Not desirable on hillslopes because it tends to float and blow away.

Wood Cellulose Fiber Mulch (Hydromulch)

Hydromulch is short fiber made from either paper or wood, and applied with a hydroseeder.

Advantages: Used where rapid mulching is essential. Inexpensive, and may be stored for long periods. No chemical additives, and no germination or growth inhibitors. Weed free, non-polluting, and biodegradable.

Disadvantages: Effective for only 30 days. Not effective in moderating soil temperature, retaining moisture, or controlling erosion. Tends to suspend seed in mulch and limit direct soil contact, and on some sites may not promote better grass/legume cover.

Leaves

Advantages: Adds nutrients to soil. Inexpensive where there is a convenient supply.

Disadvantages: Only available in the fall unless stored. Must be anchored with discing which limits application to maximum safe gradients of farm equipment.

Livestock and Poultry Manure

Advantages: Valuable source of nutrients. Increases the number of earthworms and other beneficial organisms.

Disadvantages: Difficult to spread evenly on steep hillslopes. Limited erosion control. Odor may not be acceptable.

Municipal Sewage Sludge

Advantages: Inexpensive and readily available source of organic matter.

Disadvantages: Must be digested, stabilized, or composted prior to application. Potential plant toxicity from heavy metals and other substances. Must be tested prior to use.

Mats and Fabrics

Advantages: Effective on severe sites (terrain and/or weather) and critical areas (ditches). Organic mats (excelsior, jute, straw, coconut fiber) are biodegradable.

Disadvantages: Expensive. Must be anchored with staples or pegs. Inorganic mats (fiberglass, polypropylene, vinyl) are not biodegradable, and not appropriate for National Parks.

REFERENCES: This section paraphrased from Thorne, 1987, p. 38, USFS, no date, p. 24.